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INVESTIGATIONAL REPORT No 13.

THE DEVELOPMENT OF THE CAPE STOCKFISH

(MERLUCCIUS CAPENSIS).

(CONTRIBUTION No 1.)

BY

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Introduction.

Lack or paucity of information regarding the eggs and young of fishes is consistently a basic cause of failure to solve a great many of the difficult problems arising in fisheries research.

In this respect this country is particularly poorly placed since, apart from the investigations of Gilchrist (1904, 1905, 1916 and 1918), relatively little work has hitherto been done on the development of South African fishes.

This contribution is therefore a first modest attempt to supplement our very scanty knowledge of the egg and early developmental stages of the Cape Stockfish or Hake (*Merluccius capensis*), the most important of our trawl-caught species.

Methods.

Great difficulty was experienced in obtaining male and female fish in perfectly ripe condition, and in most cases a disproportionately large number of otter-trawl drags on the stockfish grounds were necessary to achieve success. At all times ripe running males were very much more abundant in catches containing spawning fish than similarly-conditioned females. Furthermore, while microscopic examination and drawing of the various earlier stages of development were anything but facilitated by the lively movement of the ship, the seawater containing ova became putrid very rapidly, and constant care had to be taken in removing the ova to fresh seawater. Finally, the control of conditions of temperature presented fresh problems not easily surmounted.

The stockfish catches were made by R.S. " Africana " and were examined for fish in suitable condition, the larger fish being opened until a ripe running female and a ripe running male were found.

Approximately 2,000 ripe ova were removed from the female, by means of pipettes with large orifices (Just, 1939), and released in 3 inches of fresh seawater in a 10-inch by 5-inch round glass vessel. To this a few ccs. of fluid from the running milt of a male fish were added and the mixture well stirred gently with a glass rod.

Two hours after fertilization the ova were scooped out with a watchglass and placed in a similar vessel in fresh seawater. As soon as fertilization was seen to have taken place, the ship was headed for home. Cleavage and development were continuously observed and drawings of the different stages were made every half hour.

Various methods of treatment of the fertilized ova were tried during the developmental period. So, for example,

(*a*) eggs were kept in a vessel with still water, which was changed regularly every two hours ;

(*b*) a vessel with still water was kept in another with running seawater so as to maintain as constant a temperature as possible ;

(*c*) also a vessel with aerated, sterilized seawater was kept in another with running seawater ; and

(*d*) lastly, a vessel was supplied with running seawater fed from a higher-placed vessel by means of a constant-level siphon, to eliminate all air bubbles that might damage the eggs.

It was found that the last method gave the best results. The sterilized seawater method proved to be completely unsuccessful.

To date all attempts to keep the larvae alive beyond the two-and-a-half day's stage have failed. Removal of dead larvae and unhatched eggs without injurious disturbance of the live larvae presented some considerable difficulty, and it would seem that such necessary manipulations may be a mortality factor.

It is hoped, however, that with revised methods, the larvae may in future experiments be successfully kept alive beyond the two-and-a-half-days' stage.

Our sincere thanks are due to Dr. J. M. Marchand, Assistant Director of Fisheries, for his guidance and criticism, and to Dr. S. G. Gibbons, Professional Officer, for helping with the drawings.

Eggs.

The eggs of the stockfish are spherical and transparent with an average diameter of 1·033 mm. They possess one oil globule with an average diameter of 0·16 mm. Gilchrist's (1916) corresponding measurements are 0·95 mm. and 0·25 mm. The egg membrane is thin and horny. Between the egg membrane and the delicate vitelline membrane enclosing the yolk sac there is a perceptible perivitelline space.

Blastodisc.

The formation of the blastodisc takes place about one and a half hours after fertilization. Protoplasm slowly accumulates at the animal pole and becomes less transparent and almost whitish in colour. The completed blastodisc is lenticular in shape, and owing to the buoyancy of the oil globule, now hangs at the lower end of the egg. Its periphery fades away almost imperceptibly into the very thin layer of protoplasm which remains at the surface of the yolk sphere.

Cleavage.

Cleavage takes place approximately two hours after fertilization and results in the formation of two equally sized blastomeres. The furrow dividing the two does not, however, cut right through the blastodisc, but leaves a thin connexion of protoplasm at their edges that joins the two blastomeres together, and is continuous with the thin layer of protoplasm at the surface of the yolk.

The second cleavage takes place about half an hour after the first by means of another furrow perpendicular to the first. The four blastomeres thus formed are flat and more or less equally sized.

Three hours after fertilization, the third cleavage takes place by means of two furrows which appear simultaneously on each side of, and parallel to, the first plane of cleavage. The whole process is completed in about ten minutes. The eight blastomeres thus formed are arranged in two lines of four each. It is of interest to note that the two outer pairs of cells are larger than the two inner pairs. Up to this stage all the segments remain connected by broad protoplasmic bridges, apart from the continuous basal layer of protoplasm connecting the deeper cells as mentioned above.

The fourth cleavage takes place four hours after fertilization. It is the result of two parallel furrows appearing on each side and parallel to the second cleavage plane. The sixteen cells thus formed are not all of the same size and form a rounded cap next to the yolk.

As previously stated, the cleavage furrows have not cut right through the blastodisc but have left a thin layer of protoplasm joining the cells at their bases next to the yolk. This thin layer of protoplasm at the surface of the yolk becomes concentrated at the periphery of the blastoderm to form a somewhat flattened ridge. The peripheral protoplasmic ridge was called periblast by Agassiz and Whitman in 1885 (Kerr, 1919). More or less at this stage the segmentation cavity is formed. It is the result of the inner blastomeres drawing away from the central periblast and thus forming a small cavity which rapidly expands.

Blastodermal Cap.

The fifth and following cleavage stages cannot easily be followed but their occurrence can be seen by the increase of cells and the formation of a well-rounded, dome-shaped blastodermal cap closely resembling a blastodisc. The cells are now so small that they cannot be distinguished. It is interesting to note that up to the fifth cleavage stage the whole process is of a very rhythmical nature. Subsequently it is difficult to observe the intervals of rest and activity. The blastodermal cap slowly becomes more concave with the result that the segmentation cavity becomes larger. With the enlarging of the segmentation cavity the central portion of the blastodermal cap becomes thinner, while there is a well-marked groove which shows the actual area of the germ ring. This groove then marks the line along which involution of the egg surface is taking place, and its animal lip (side of micromeres) represents the lip of the gastrula. With the appearance of the germ ring the embryonic shield starts to form and develops to a broad area of cells. At 23 hours after fertilization a thickening along the median line of the embryonic shield can be seen, and the general body outline of the embryo can readily be distinguished.

The germ ring at the anterior end of the embryonic shield now starts moving away from it and begins a centrifugal growth. It spreads over the equatorial position and comes together at the caudal end of the embryo at about 38 hours after fertilization. After the completion of the gastrulation, marked by the simultaneous closure of the blastopore, the eyes, not yet containing pupils, can be observed. Already the developing notochord, as well as myotomes, can be distinguished faintly. The caudal part of the body now lengthens quickly with the addition of somites and the embryo encircles a major portion of the large yolk sac upon which are pigment cells in scattered position.

At about 45 hours the head of the embryo is quite well-formed and the pupils in the eyes have developed. A slight bulge, the developing heart, can now be distinguished just posterior to the nape of the neck. The body has increased in bulk but up to now melanophores can only be seen very faintly. At $\pm$ 48 hours the head has a flattened form with the two outstanding eyes well-rounded and protruding. The heart, now well developed, starts pulsating and spasmodic movements of the body can be seen.

The tail, now encircling most of the yolk sac, loosens its posterior part from it. By this time the development of the brain is well advanced and the neural canal, the "anlage" of the nervous system, can readily be observed. There is an increase of melanophores along the dorsal part of the body. The posterior portion of the alimentary tract,

the first signs of the developing internal ears and the pectoral fins, appearing as rounded folds, can be distinguished.

Hatching.

From this stage to the time of hatching no further observable major changes take place apart from the enlarging of the whole body and of the organs already developed. The melanophores become more pronounced and the twitchings of the tail much stronger. These tail movements seem to be transmitted to the head which rests against the shell of the egg. As a result of these head movements, a rupture appears in the shell at about 60 hours, and one hour after that the larva is liberated.

Larva.

Due to the yolk sac and oil globule, the larva floats helplessly upside down on the surface of the water. By movements of the tail it is able to swim about, only to come to the surface again when the movements stop. About seven hours after hatching, the larvae are quite capable of moving about, but usually lie quietly at varying depths near the surface.

The average length of the larva is 2·35 mm. No indication of an oral opening was seen in larvae up to 36 hours. The body is tapered to the tail and melanophores are generally distributed with greater concentrations around the eyes, back and tail. The ovoid yolk sac extends from beneath the snout to the rectum which is slightly behind the midpoint of the body. The oil globule is in the postero-ventral section of the yolk sac. The fin folds are continuous, the dorsal fold arising just posterior to the head and the ventral fold is continuous with the yolk sac. The fin folds and the posterior tip of the body are transparent. The internal ear is clearly seen and the pectoral fins are much larger.

At 38 hours after hatching the yolk sac is very much smaller due to absorption, and the rectum can be seen as a straight tube above and behind it. The pectoral fins are now quite large and the first fin rays of the tail fin can be distinguished. The brain is well developed and the body has attained a length of 3·8 mm.

Summary.

(1) Fertilization of the eggs of the Cape Stockfish or Hake (*Merluccius capensis*) was carried out artificially on board the R.S. " Africana " and the development of the eggs and larvae up to the two-and-a-half-day's stage after hatching was observed.

(2) The average diameter of the stockfish egg is 1·033 mm., and that of the oil globule 0·16 mm.

(3) The formation of the blastodisc takes place approximately 1½ hours after fertilization.

(4) The first cleavage occurs two hours after fertilization and is rapidly followed by the successive stages.

(5) Up to the fifth cleavage stage the process is a rhythmical sequence, after which it is difficult to observe the intervals of rest and activity.

(6) At 23 hours after fertilization the general body outline of the embryo can readily be distinguished.

(7) The eyes can be observed after the completion of gastrulation, which is marked by the simultaneous closure of the blastopore.

(8) At 45 hours the main internal organs can be identified ; a slight bulge, just posterior to the nape of the neck, represents the heart.

(9) The heart starts pulsating at 48 hours and body movements occur from time to time.

(10) The inner ear and pectoral fins are apparent just before hatching.

(11) The larva is liberated at approximately 60 hours after fertilization by vigorous movement of the head and tail.

(12) The average length of the larva after hatching is 2·35 mm.

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Explanation of Plates.

PLATE 1.

Merluccius capensis.

Fig. 1.—Blastodisc..... 1½ hours.

Fig. 2.—1st cleavage..... 2 hours.

Fig. 3.—2 cells..... 2 hours.

Fig. 4.—4 cells..... 2½ hours.

Fig. 5.—8 cells..... 3 hours.

Fig. 6.—16 cells..... 4 hours.

Fig. 7.—Early blastodermal cap..... 8 hours.

Fig. 8.—Completed blastodermal cap.. 13 hours.

Fig. 9.—Segmentation cavity..... 14 hours.

PLATE 2.

Merluccius capensis.

Fig. 10.—Area of germ ring..... 18 hours.

Fig. 11.—Embryonic shield..... 23 hours.

Fig. 12.—Germ ring approaching equatorial position 36 hours.

Fig. 13.—Embryo after closure of blastopore 42 hours.

Fig. 14.—Advanced stage of developing embryo 45 hours.

Fig. 15.—Embryo shortly before hatching 58 hours.

PLATE 3.

Merluccius capensis.

Fig. 16.—Larva a few hours after hatching.

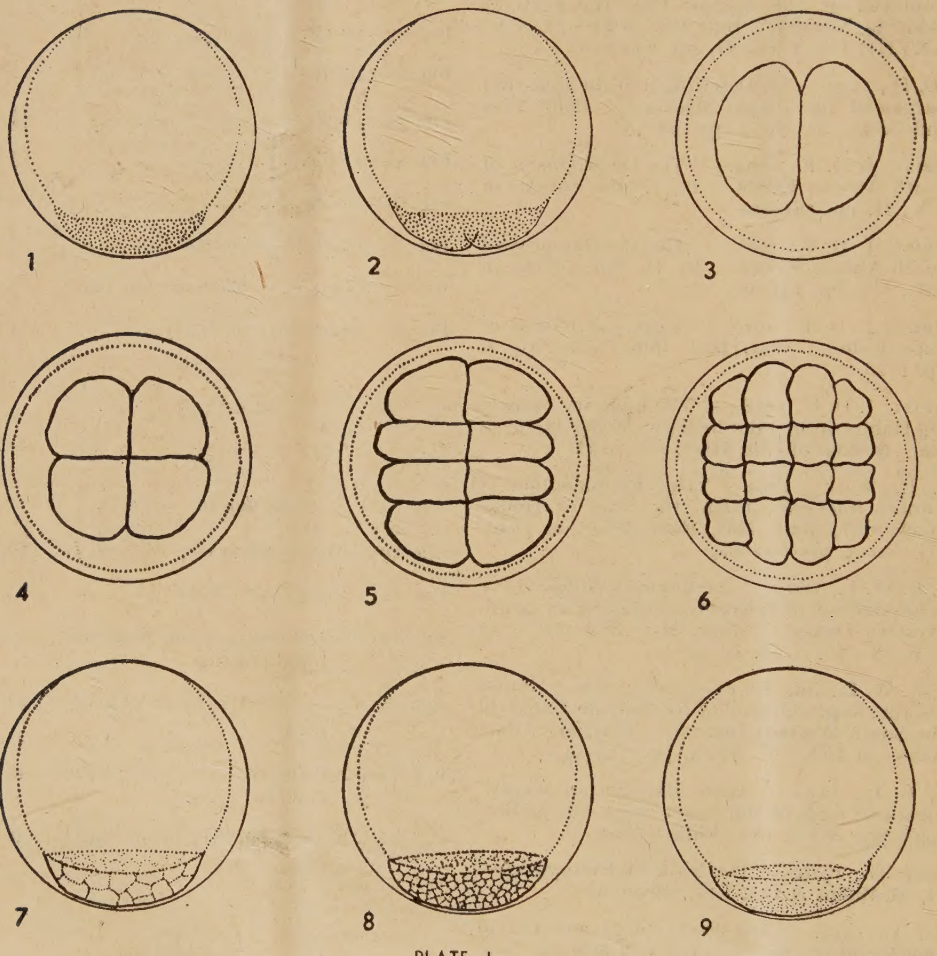

PLATE I.

PLATE II.

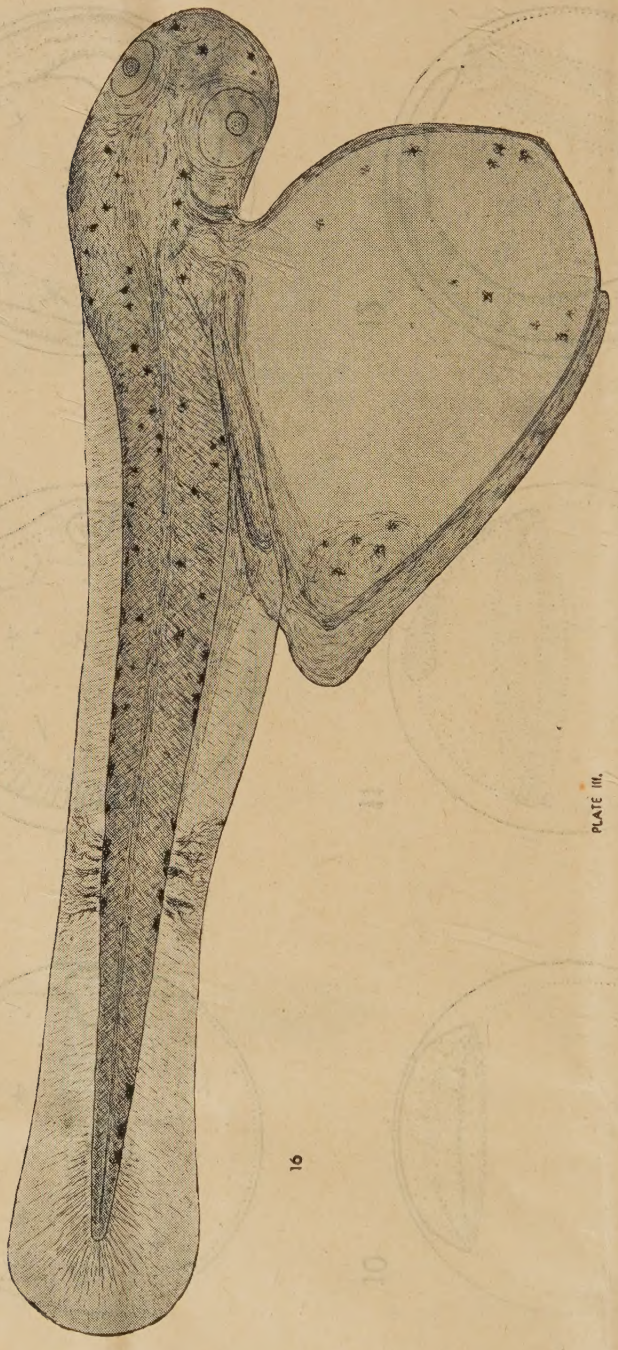

PLATE III.

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